

Estrous behavior and initiation of estrous cycles in postpartum Brahman-influenced cows after treatment with progesterone and prostaglandin $F_{2\alpha}$ ^{1,2}

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ABSTRACT: Spring-calving, crossbred (1/4 to 3/8 Brahman) primiparous (n = 56) and multiparous (n = 102) beef cows were used to evaluate the effects of progesterone, delivered via a controlled internal drug-releasing (CIDR) device, and prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) on estrous behavior, synchronization rate, initiation of estrous cycles, and pregnancy rate during a 2-yr period. To determine luteal activity, weekly blood samples were collected 3 wk before initiation of a 75-d breeding season. Treated cows received a CIDR for 7 d beginning on d -7 of the breeding season. On d 0, CIDR were removed, and cows receiving CIDR were administered $PGF_{2\alpha}$; control cows received no treatment. Cows were exposed to bulls, and estrous activity was monitored using a radiotelemetry system for the first 30 d of the breeding season. Treatment with CIDR- $PGF_{2\alpha}$ increased ($P < 0.05$) the number of mounts received (22.5 ± 3.0 vs. 13.7 ± 3.9 for CIDR- $PGF_{2\alpha}$ vs. untreated control cows, respectively) but did not influence duration of estrus or quiescence between mounts. Number of mounts received and duration of estrus were greater ($P < 0.05$) in multiparous compared with primiparous cows. Synchronization of estrus was greater ($P < 0.05$)

in cows treated with CIDR- $PGF_{2\alpha}$ (56%) compared with control cows (13%) during the first 3 d of the breeding season. More ($P < 0.05$) anestrous cows treated with CIDR- $PGF_{2\alpha}$ than anestrous control cows were in estrus during the first 3 d (59 vs. 12%) and 30 d (82 vs. 63%) of the breeding season. Treatment with CIDR- $PGF_{2\alpha}$ decreased ($P < 0.05$) the interval to first estrus after treatment during the first 30 d of the breeding season compared with control cows (5.5 ± 1.1 vs. 9.0 ± 1.4 d). First service conception rate was greater ($P < 0.05$) in CIDR- $PGF_{2\alpha}$ -treated cows compared with control cows. Cyclic cows at initiation of the breeding season had an increased ($P < 0.05$) 75-d pregnancy rate compared with anestrous cows, and the pregnancy rate tended ($P = 0.10$) to be greater in multiparous compared with primiparous cows. We conclude that treatment of Brahman-influenced cows with progesterone via a CIDR for 7 d, along with administration of $PGF_{2\alpha}$ at CIDR removal, increases the number of mounts received, improves synchronization and first service conception rates, decreases the interval to first estrus after treatment, and may be effective at inducing estrous cycles in anestrous cows.

Key words: anestrous, beef cow, estrous behavior, progesterone, prostaglandin

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J. Anim. Sci. 2006. 92:1916–1925
doi:10.2527/jas.2005-692

INTRODUCTION

Synchronization of estrus in both beef and dairy cattle has been accomplished with progestins (Zimbleman and Smith, 1966; Wiltbank and Gonzalez-Padilla,

1975), prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$; Lauderdale, 1972; Lauderdale et al., 1974), and combinations of these and other hormones (Odde, 1990; Patterson et al., 2003). Recently, a controlled internal drug-releasing (CIDR) device containing progesterone (P_4) along with $PGF_{2\alpha}$ has effectively synchronized estrus in beef cows and heifers and reduced the interval to estrus in anestrous suckled beef cows (Lucy et al., 2001). Estrous

¹Names are necessary to report factually on available data; however, the USDA does not guarantee or warrant the standard of the product, and the use of the name by the USDA implies no approval of the product to the exclusion of others that also may be suitable.

²This study was supported in part by USDA, Agricultural Research Service cooperative agreement #58-6227-8-040. The authors gratefully acknowledge L. Huddleston, W. Jackson, G. Robson, and D. Jones, USDA-ARS, for technical assistance and daily animal management.

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Received November 28, 2005.

Accepted January 25, 2006.

synchronization with P_4 has been conducted with Brahman heifers with CIDR-PGF_{2 α} (Lemaster et al., 1999) and Brahman-influenced cows with CIDR-GnRH (Lemaster et al., 2001), norgestomet-PGF_{2 α} (Williams et al., 2002), or melengestrol acetate (MGA)-GnRH-PGF_{2 α} (Hiers et al., 2003). Effects of a CIDR-PGF_{2 α} treatment on estrous characteristics of Brahman-influenced cows are lacking.

Decreased body energy reserves result in fewer cows in estrus during the breeding season (Richards et al., 1986; Spitzer et al., 1995), and body condition losses usually are more detrimental to the reproductive performance of primiparous cows than mature cows (Spitzer et al., 1995; Ciccioli et al., 2003). The number of anestrus cows at breeding limits the efficacy of various synchronization programs and decreases fertility (Wettemann, 1980; Short et al., 1990; Williams, 1990). Progestins shorten the postpartum interval in cattle (Short et al., 1976; Miksch et al., 1978; Smith et al., 1987); however, less is known of effects of P_4 via a CIDR and PGF_{2 α} on resumption of estrous cycles in anestrus Brahman-influenced cows.

The objectives of this experiment were to evaluate the influence of P_4 for 7 d via a CIDR, followed by PGF_{2 α} at CIDR removal on 1) estrous behavior, synchronization, first service conception, and pregnancy rates of cyclic Brahman-influenced cows, and 2) the initiation of estrous cycles in anestrus Brahman-influenced cows.

MATERIALS AND METHODS

Description of Animals and Experimental Procedures

The committee for animal welfare at the USDA-ARS, Dale Bumpers Small Farms Research Center, Booneville, AR, approved all animal procedures used in this study. Spring-calving crossbred (1/4 to 3/8 Brahman), primiparous [$n = 56$; BW = 381 ± 14 kg; BCS = 4.8 ± 0.2 (1 = emaciated to 9 = obese; Wagner et al., 1988); days postpartum = 87 ± 5] and multiparous ($n = 102$; BW = 552 ± 9 kg; BCS = 6.2 ± 0.1 ; days postpartum = 81 ± 3) cows were utilized during 2 yr. Primiparous and multiparous cows with calves were maintained in the same pastures of common bermudagrass [*Cynodon dactylon* (L.) Pers.; 1 cow/0.4 ha] throughout the 30-d experiment.

Three weeks before initiation of the breeding season (initiation date = May 24 and 12 for yr 1 and 2, respectively), weekly blood serum samples were collected from each cow by venipuncture of the median caudal vein, allowed to clot for 24 h at 4°C, and centrifuged ($1,500 \times g$ for 25 min). Serum samples were stored at -4°C until concentrations of P_4 were quantified by RIA (Patterson et al., 1995; Coat-A-Count, Diagnostic Products, Los Angeles, CA) to determine luteal activity. Intra- and interassay CV were 3 and 5%, respectively. Cows were classified as cyclic (concentrations

of $P_4 \geq 1$ ng/mL in 2 consecutive weekly blood samples) or anestrus (concentrations of $P_4 < 1$ ng/mL in 2 consecutive weekly blood samples) at the initiation of the breeding season.

Cows were blocked by BCS, parity, and luteal activity status, and assigned to receive either P_4 (via CIDR, 1.38 g of P_4 ; Pharmacia & Upjohn Co., Kalamazoo, MI; $n = 88$) for 7 d followed by administration of PGF_{2 α} (Lutalyse, 25 mg i.m.; Pharmacia & Upjohn Co.) or no treatment (control; $n = 70$). Control cows were handled through a livestock chute in a manner similar to that used for the CIDR-PGF_{2 α} -treated cows.

A CIDR was inserted into the vagina of each cow in the treated group on d -7 of the breeding season and was removed on d 0. Cows in the treatment group were administered PGF_{2 α} on the day of CIDR removal. On d -7 of the breeding season, all cows were fitted with a radiotelemetry (Heatwatch, HW; DDx Inc., Denver, CO) transmitter, and estrous activity was recorded during the first 30 d of the 75-d breeding season. Activities associated with estrus were recorded for each cow and included date and time of onset of estrus, number of mounts received, duration (h) of estrus, and quiescent period. Mean quiescence was defined as the interval between each successive mount and was calculated as: mean quiescence period = duration of estrus (h)/number of mounts received - 1. Mounts were standing events lasting 2 s or more between the beginning and end of estrus, as detected by the HW system. The first of 2 mounts within 4 h determined onset of estrus. Termination of estrus was the final mount, with a single mount 4 h previously, and no activity the next 12 h (White et al., 2002). Estrous data were not recorded during the first 30 d of the breeding season for 13 and 23 cows in the CIDR-PGF_{2 α} treatment and control groups, respectively. Cows that lost their HW transmitter after initiation of estrus were removed from the statistical analyses for synchronization rate and estrous characteristics but were included in analyses determining the proportion of cows in estrus and interval to estrus after treatment. Cows were exposed to bulls (1 bull/21 cows) during a 75-d breeding season, and cows were palpated 45 to 60 d after the breeding season to determine pregnancy.

Synchronization rate was defined as the number of cows that exhibited behavioral estrus as detected by HW during the first 3 d of the breeding season after treatment divided by the total number of cows in each group. First service conception rate was defined as the number of cows detected in estrus via HW that became pregnant divided by the total number of cows with a HW-detected estrus during the first 3 d of the breeding season. Date of first service conception was determined by subtracting 285 d from the calf's birth date. Pregnancy rate was defined as the number of cows that became pregnant during the first 3 d and the entire 75-d breeding season divided by the total number of cows in each group.

Statistical Analyses

Days postpartum, BW, and BCS at treatment were analyzed by ANOVA utilizing the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). The model included treatment, parity, and the interaction. The percentage of anestrous cows was analyzed with the CATMOD procedure of SAS, with a model that included treatment, parity, and the interaction.

The effect of treatment, parity, luteal activity status at initiation of the breeding season, year, and all interactions on the number of mounts received, the duration of estrus, and the quiescence between mounts was analyzed by ANOVA using the MIXED procedure of SAS, with a completely randomized design. The interaction of treatment \times year was not significant ($P > 0.10$); consequently, data were pooled across both years.

The PROC CORR procedure of SAS was used to analyze the simple correlation between duration of estrus and number of mounts received. Cows responding to estrous synchronization were expected to be in estrus within the first 3 d of the breeding season. The percentage of cows exhibiting estrus during the first 3 d; estrous characteristics on d 1, 2, or 3; first service conception rates on d 1, 2, or 3; and the 3-d cumulative pregnancy rates were analyzed with the CATMOD procedure of SAS. The models included treatment, parity, luteal activity status at breeding, and all interactions.

These statistical analyses also were performed on data collected during the first 30 d of the breeding season and included the percentage of cows exhibiting estrus, estrous characteristics, and pregnancy rate for the 75-d breeding season. Body weight and BCS were used as a covariate in each of the models just discussed. Body weight was not significant ($P > 0.10$) in any of the models. When BCS was significant ($P < 0.05$), it was categorized into 1 of 2 categories (BCS ≤ 5 and BCS > 5) and subsequently was analyzed as an independent variable along with treatment, parity, luteal activity status at breeding, and all interactions.

Mean interval to first estrus after CIDR removal and PGF_{2 α} treatment was analyzed using the GLM procedure of SAS, with a model that included the effect of treatment, luteal activity status at breeding, and the interaction. Survival analysis utilizing the LIFETEST procedure of SAS was used to evaluate the effects of treatment, parity, and luteal activity status at breeding on detection of estrus and pregnancy rate during the first 30 d of the breeding season. For interval to first estrus, the survival analysis utilized the number of cows not detected in estrus with the radiotelemetry system during the first 30 d of the breeding season, and cows not detected in estrus were included in the statistical analysis as censored observations. The Wilcoxon test was used to examine differences between the survival curves. Initially, treatment and luteal activity status at breeding were tested independently as 2 different strata. Treatment effects were then tested

for data sorted by luteal activity status (cyclic or anestrous) at breeding. Survival analysis for interval to pregnancy during the first 30 d of the breeding season was performed using the aforementioned methods for interval to first estrus. Cows that were detected in estrus during the first 30 d of the breeding season, exposed to bulls, and did not become pregnant were censored for pregnancy analyses. Because parity of each cow was thought to be related to the survival time, the effect of treatment was tested when adjusting for the parity of the cow by specifying parity as a variable in the strata statement.

RESULTS

Mean BW, BCS, days postpartum, and the number of anestrous cows were similar ($P > 0.10$) between CIDR-PGF_{2 α} -treated and control cows at the initiation of the experiment (Table 1). Multiparous cows were heavier ($P < 0.05$; 552 ± 9 vs. 381 ± 14 kg) and had greater BCS ($P < 0.05$; 6.2 ± 0.1 vs. 4.8 ± 0.2) at the initiation of the breeding season compared with primiparous cows (Table 1). Sixty-one percent (96/158) of all cows were classified as anestrous at the initiation of the breeding season. A greater percentage ($P < 0.05$) of primiparous cows (82%; 46/56) was anestrous at the initiation of the breeding season than multiparous cows (49%; 50/102).

No effect of luteal activity at the initiation of the breeding season or CIDR-PGF_{2 α} treatment ($P > 0.10$) was observed for the mean number of mounts received or mean duration of estrus during the first 3 d of the breeding season (Table 2). Mean number of mounts received was 23.5 ± 8.8 , and the duration of estrus was 7.1 ± 1.9 h. Mean quiescence between mounts during the first 3 d of the breeding season was greater ($P < 0.05$) in cyclic cows (2.3 ± 0.5 h) compared with anestrous cows (1.0 ± 0.5 h; Table 2).

Cows treated with CIDR-PGF_{2 α} had a greater ($P < 0.05$) number of mounts received (22.5 ± 3.0) compared with control cows (13.7 ± 3.9 ; Table 3) during the first 30 d of the breeding season. An effect of BCS ($P < 0.05$) on mean number of mounts received was observed when BCS was included as a covariate in the main statistical model. However, when BCS was tested categorically as an independent variable, BCS did not influence ($P > 0.10$) mean number of mounts. Mean duration of estrus (5.6 ± 0.8 h) and mean quiescence between mounts (1.2 ± 0.3 h) were not different ($P > 0.10$) between CIDR-PGF_{2 α} -treated and control cows (Table 3). Duration of estrus and the number of mounts received were positively correlated ($r = 0.62$; $P < 0.001$).

Parity influenced ($P < 0.05$) estrous characteristics during the first 30 d of the breeding season (Table 3). Multiparous cows had greater ($P < 0.05$) number of mounts received (24.8 ± 2.7 vs. 11.3 ± 4.2), duration of estrus (7.6 ± 0.7 vs. 3.5 ± 1.0 h), and quiescence between mounts (1.9 ± 0.3 vs. 0.5 ± 0.4) compared with primiparous cows during the first 30 d of the breeding season (Table 3).

Table 1. Body weight, BCS, days postpartum, and number of anestrous, primiparous, and multiparous Brahman-influenced cows treated with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin F_{2α} (PGF_{2α}) or not treated (control)

Variable	Treatment ¹				P value		
	Control		CIDR-PGF _{2α}		Trt	Parity	Trt × Parity
	Primiparous	Multiparous	Primiparous	Multiparous			
No. of cows	22	48	34	54	—	—	—
BW, kg	390.3 ± 15.9	545.1 ± 10.3	371.8 ± 11.7	559.6 ± 8.3	0.87	0.001	0.17
BCS ²	4.8 ± 0.2	6.2 ± 0.1	4.8 ± 0.2	6.3 ± 0.1	0.89	0.001	0.83
Postpartum, d	89.6 ± 5.3	83.9 ± 3.4	84.3 ± 3.9	77.4 ± 2.7	0.13	0.11	0.88
No. anestrus ³	18 (82)	22 (46)	28 (82)	28 (52)	0.73	0.001	0.80

¹Trt = control (no CIDR-PGF_{2α}) vs. CIDR-PGF_{2α}; least squares means ± SE.²1 = emaciated; 9 = obese (Wagner et al., 1988).³Percentages in parentheses.**Table 2.** Influence of luteal activity (LA) at initiation of the breeding season and progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin F_{2α} (PGF_{2α}) or no treatment (control) on estrous characteristics, synchronization rate, first service conception rate, and pregnancy rate of Brahman-influenced cows during the first 3 d of the breeding season

Variable	Luteal activity ¹				P value		
	Cyclic		Anestrus		Trt ²	LA	Trt × LA
	Control	CIDR-PGF _{2α}	Control	CIDR-PGF _{2α}			
No. of cows	22	29	25	46	—	—	—
No. of mounts received	13.3 ± 12.6	27.1 ± 5.7	22.3 ± 12.6	31.1 ± 4.3	0.25	0.50	0.80
Range	11 to 16	3 to 65	12 to 39	3 to 93	—	—	—
Duration of estrus, h	6.8 ± 2.7	8.5 ± 1.2	6.6 ± 2.7	6.5 ± 0.9	0.69	0.60	0.65
Range	6.1 to 8.3	2.0 to 17.7	5.6 to 8.3	0.3 to 17.7	—	—	—
Quiescence between mounts, h	2.3 ± 0.7	2.3 ± 0.3	1.2 ± 0.7	0.8 ± 0.2	0.76	0.02	0.72
Range	2.1 to 5.2	0.1 to 4.9	0.5 to 2.1	0.1 to 4.3	—	—	—
Synchronization rate, ³ %	14 (3/22)	52 (15/29)	12 (3/25)	59 (27/46)	0.001	0.89	0.67
First service conception rate, ³ %	0 (0/3)	40 (6/15)	67 (2/3)	44 (12/27)	0.01	0.02	0.87
Pregnancy rate, ³ %	0 (0/22)	21 (6/29)	8 (2/25)	26 (12/46)	0.003	0.08	0.97

¹Cyclic = progesterone ≥1.0 ng/mL in 2 consecutive weekly blood samples collected 3 wk before initiation of the breeding season; Anestrus = progesterone < 1.0 ng/mL in 2 consecutive weekly blood samples; least squares means ± SE.²Trt = control (no CIDR-PGF_{2α}) vs. CIDR-PGF_{2α}.³Number of observations in parentheses.**Table 3.** Influence of parity and treatment with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin F_{2α} (PGF_{2α}) or no treatment (control) on estrous characteristics during the first 30 d of the breeding season and cumulative 75-d breeding season pregnancy rate of Brahman-influenced cows

Variable	Treatment ¹				P value		
	Control		CIDR-PGF _{2α}		Trt	Parity	Trt × Parity
	Primiparous	Multiparous	Primiparous	Multiparous			
No. of cows	22	25	29	46	—	—	—
No. of mounts received	7.5 ± 4.8	19.9 ± 2.9	15.2 ± 3.5	29.7 ± 2.4	0.01	0.002	0.77
Range	3 to 22	4 to 77	3 to 75	3 to 93	—	—	—
Duration of estrus, h	2.9 ± 1.1	7.1 ± 0.7	4.1 ± 0.8	8.1 ± 0.6	0.17	0.001	0.89
Range	0.3 to 6.7	1.6 to 15.6	0.3 to 13.1	1.2 to 17.7	—	—	—
Quiescence between mounts, h	0.6 ± 0.4	1.8 ± 0.3	0.4 ± 0.3	1.9 ± 0.2	0.80	0.001	0.72
Range	0.1 to 1.4	0.2 to 7.1	0.1 to 1.4	0.1 to 6.6	—	—	—
Pregnancy rate, ² %	55 (12/22)	88 (22/25)	72 (21/29)	91 (42/46)	0.57	0.10	0.98

¹Trt = control (no CIDR-PGF_{2α}) vs. CIDR-PGF_{2α}; least squares means ± SE.²Cumulative 75-d breeding season pregnancy rate; number of observations in parentheses.

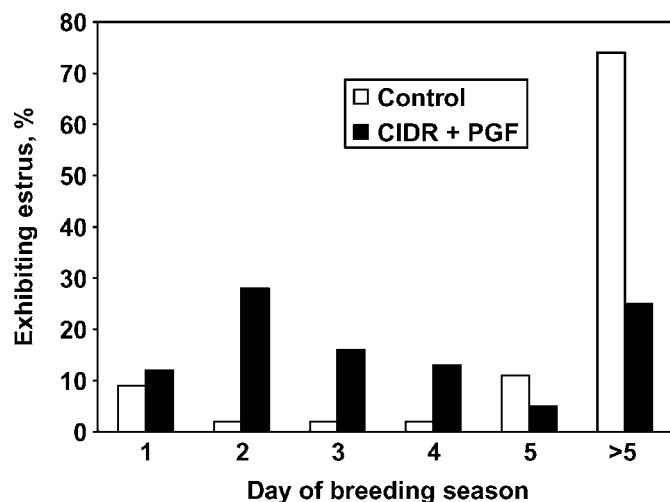


Figure 1. Percentage of primiparous and multiparous, Brahman-influenced cows detected in estrus at various days of the breeding season after treatment with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or no treatment (control). Treatment $P < 0.05$, parity $P > 0.10$, luteal activity status $P > 0.10$.

During the first 3 d of the breeding season, a greater ($P < 0.05$) percentage of CIDR- $PGF_{2\alpha}$ -treated cows (56%) were detected in estrus compared with control cows (13%; Table 2). Cows in estrus during the first 3 d of the breeding season were assumed to be synchronized in response to CIDR- $PGF_{2\alpha}$ treatment. Luteal activity status at the initiation of the breeding season did not ($P > 0.10$) influence the percentage of cows exhibiting estrus during the first 3 d of the breeding season. Treatment of anestrus cows at the initiation of the breeding season with CIDR- $PGF_{2\alpha}$ increased ($P < 0.05$) the percentage of cows exhibiting estrus during the first 3 d of the breeding season compared with control cows (Table 2). Similarly, a greater ($P < 0.05$) percentage of cyclic cows treated with CIDR- $PGF_{2\alpha}$ exhibited estrus during the first 3 d of the breeding season compared with control cows (Table 2). On the first 4 d of the breeding season, a greater ($P < 0.05$) percentage of CIDR- $PGF_{2\alpha}$ -treated cows were detected in estrus compared with control cows (Figure 1).

First service conception rates were greater ($P < 0.05$) in CIDR- $PGF_{2\alpha}$ -treated cows compared with control cows (Table 2). Due to the limited number of control cows exhibiting estrus during the first 3 d of the breeding season, luteal activity status influenced ($P < 0.05$) first service conception rate (Table 2). Cumulative 3-d pregnancy rate was greater ($P < 0.05$) in CIDR- $PGF_{2\alpha}$ -treated cows (24%) than control cows (4%).

Treatment with CIDR- $PGF_{2\alpha}$ increased ($P < 0.05$) the percentage of cows exhibiting estrus during the first 30 d of the breeding season (Table 4). More cyclic cows tended ($P = 0.09$) to exhibit estrus during the first 30 d of the breeding season compared with anes-

trous cows (82 vs. 74%, respectively; Table 4). Treatment influenced ($P < 0.05$) the interval to first estrus after treatment during the first 30 d of the breeding season; mean interval to first estrus was 5.5 ± 1.1 and 9.0 ± 1.4 d for CIDR- $PGF_{2\alpha}$ -treated and control cows, respectively (Table 4). Luteal activity status at the initiation of the breeding season did not influence ($P > 0.10$) interval to first estrus (Table 4). Pregnancy rate for the 75-d breeding season was not influenced by CIDR- $PGF_{2\alpha}$ treatment ($P > 0.10$; Table 4). However, more ($P < 0.05$) cyclic cows [90% (56/62)] were pregnant at the end of the 75-d breeding season than anestrus cows [78% (75/96); Table 4]. Pregnancy rate tended ($P = 0.10$) to be greater in multiparous cows [90% (64/71)] compared with primiparous cows [65% (33/51); Table 3].

Treatment influenced ($P < 0.05$) survival curves of the proportion of cows not detected in estrus (Figure 2a) and not pregnant (Figure 2b) during the first 30 d of the breeding season. Proportion of cows treated with CIDR- $PGF_{2\alpha}$ not detected in estrus by HW declined earlier in the breeding season than control cows (Figure 2a). Likewise, the proportion of CIDR- $PGF_{2\alpha}$ -treated cows underwent a more rapid decrease in the number of cows not pregnant during the first 30 d of the breeding season compared with control cows (Figure 2b). Luteal activity status at the initiation of the breeding season did not ($P > 0.10$) affect the proportion of cows not detected in estrus or not pregnant during the first 30 d of the breeding season.

When survival curves were adjusted for parity, the influence of treatment on survival curves for both the proportion of cows not detected in estrus and not pregnant during the first 30 d of the breeding season was different ($P < 0.05$) between parities. Treatment did not alter ($P > 0.10$) the proportion of primiparous cows not detected in estrus (Figure 3a) or the proportion of primiparous cows not pregnant during the first 30 d of the breeding season (Figure 3b). However, multiparous cows treated with CIDR- $PGF_{2\alpha}$ underwent a more rapid decline ($P < 0.05$) in proportion of cows not detected in estrus (Figure 4a) and not pregnant (Figure 4b) than control multiparous cows.

DISCUSSION

Limited data exist for effects of P_4 and $PGF_{2\alpha}$ on estrous response and behavior of Brahman-influenced cows, especially estrous characteristics monitored with a radiotelemetric system. In the current study, Brahman-influenced cows treated with CIDR- $PGF_{2\alpha}$ had an increased number of mounts received during the first 30 d of the breeding season compared with control cows; however, duration of estrus or quiescence between mounts were not different between treatments. Pinheiro et al. (1998) reported that natural or induced estrus averaged 10.9 h for Nelore (*Bos indicus*) cows observed continuously (24 h/d) for 5 d. Previous reports utilizing a radiotelemetry system with a lim-

Table 4. Influence of luteal activity (LA) at initiation of the breeding season and treatment with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or no treatment (control) on the percentage of Brahman-influenced cows detected in estrus and the interval to estrus during the first 30 d of the breeding season and cumulative 75-d breeding season pregnancy rate

Variable	Luteal activity ¹				<i>P</i> value		
	Cyclic		Anestrus		Trt ²	LA	Trt × LA
	Control	CIDR- $PGF_{2\alpha}$	Control	CIDR- $PGF_{2\alpha}$			
No. of cows	30	32	40	56	—	—	—
Estrus, %	73 (22/30)	91 (29/32)	63 (25/40)	82 (46/56)	0.02	0.09	0.69
Interval to estrus, d	9.1 ± 1.5	4.0 ± 1.2	8.8 ± 1.3	7.0 ± 1.0	0.005	0.29	0.17
Range	1 to 19	1 to 11	1 to 16	1 to 26	—	—	—
Pregnancy rate, ³ %	83 (25/30)	97 (31/32)	83 (33/40)	75 (42/56)	0.40	0.04	0.24

¹Cyclic = progesterone ≥1.0 ng/mL in 2 consecutive weekly blood samples collected 3 wk before initiation of the breeding season; Anestrus = progesterone <1.0 ng/mL in 2 consecutive weekly blood samples; least squares means ± SE.

²Trt = control (no CIDR- $PGF_{2\alpha}$) vs. CIDR- $PGF_{2\alpha}$.

³Cumulative 75-d breeding season pregnancy rate; number of observations in parentheses.

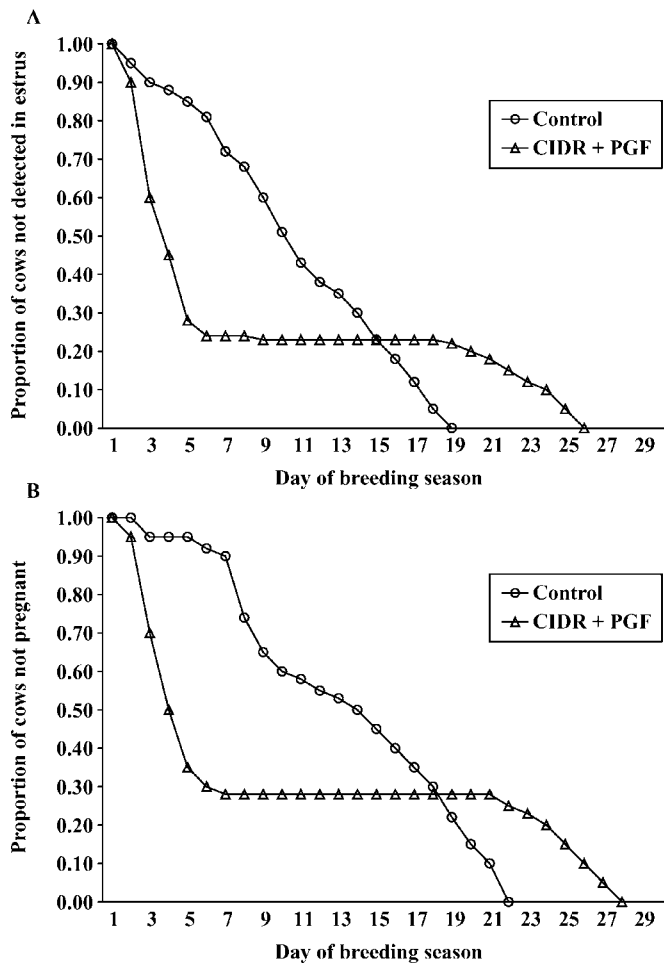


Figure 2. Survival analysis curves for the proportion of Brahman-influenced cows treated with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or no treatment (control) and not detected in estrus (A) or not pregnant (B) during the first 30 d of the breeding season. Treatment $P < 0.05$; luteal activity status, $P > 0.10$.

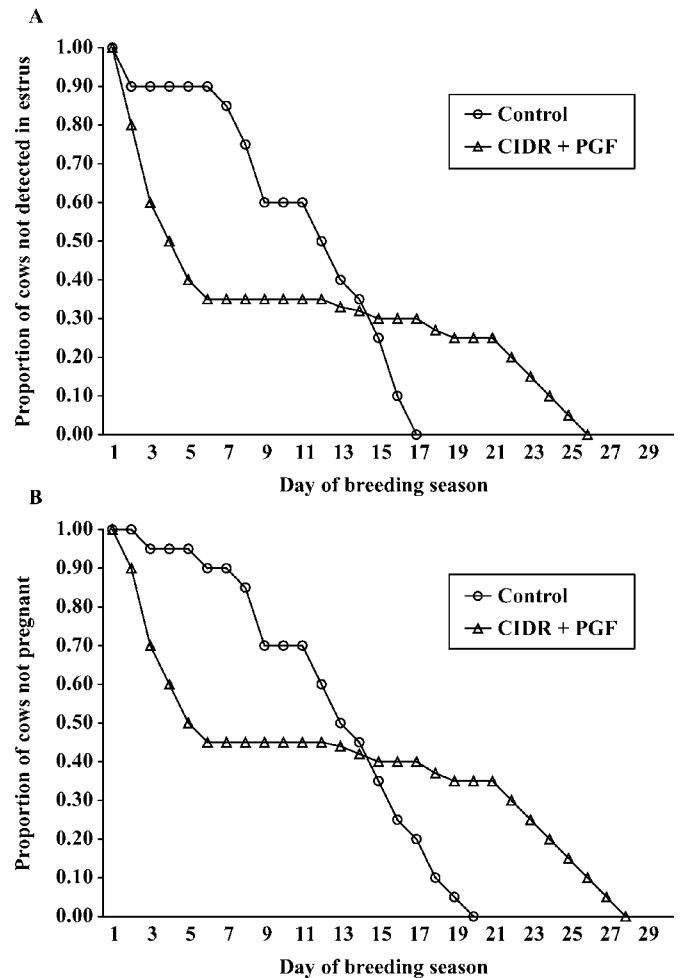


Figure 3. Survival analysis curves for the proportion of primiparous Brahman-influenced cows treated with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or no treatment (control) and not detected in estrus (A) and not pregnant (B) during the first 30 d of the breeding season. Treatment $P > 0.10$.

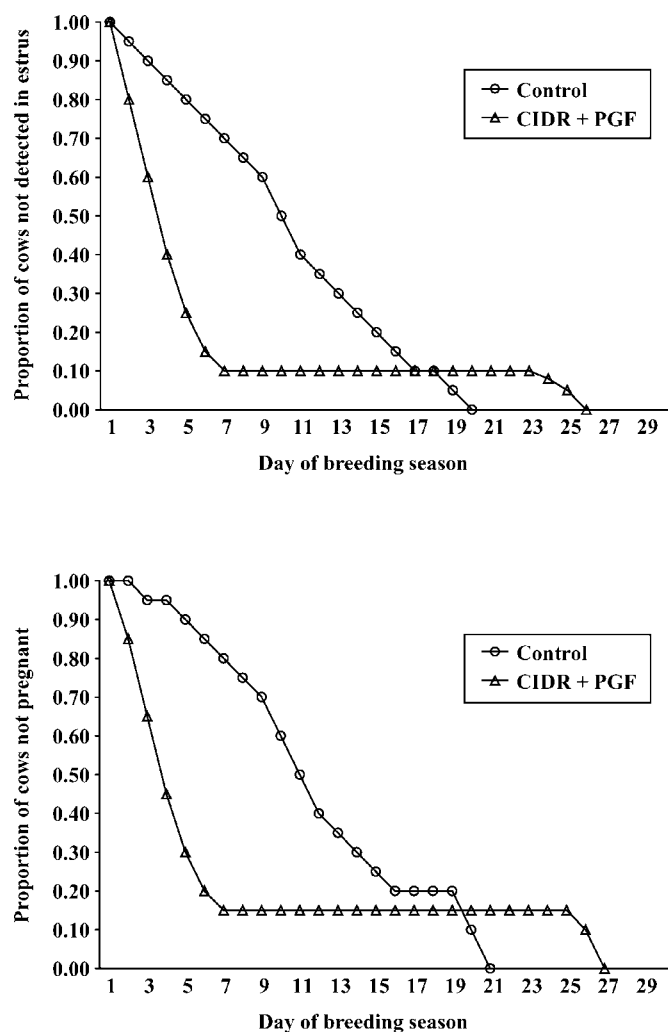


Figure 4. Survival analysis curves for the proportion of multiparous Brahman-influenced cows treated with progesterone via a controlled internal drug-releasing (CIDR) device for 7 d followed by prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) or no treatment (control) and not detected in estrus (A) and not pregnant (B) during the first 30 d of the breeding season. Treatment $P < 0.05$.

ited number of observations indicated duration of a $PGF_{2\alpha}$ -induced estrus averaged between 17 to 22 h for Brahman cows (Landaeta-Hernandez et al., 2002, 2004). Brahman-influenced heifers treated with a CIDR for 7 d with $PGF_{2\alpha}$ administration at CIDR removal had a mean duration of 14 h and received an average of 28 mounts (Lemaster et al., 1999). The number of mounts received increased almost 5-fold as the number of cows exhibiting estrus increased from 1 to 7 or more cows (Floyd et al., 2001). Synchronization results in more cows exhibiting estrus simultaneously, influencing estrous behavior. Rasby et al. (1998) found 80% of beef heifers treated with a CIDR for 7 d exhibited estrus 1 to 3 d after CIDR removal. In the current study, 56% of cows administered CIDR- $PGF_{2\alpha}$ exhibited estrus during the first 3 d of the breeding season, and the increased number of cows exhibiting estrus

influenced estrous behavior during the first 30 d of the breeding season.

Multiparous cows had increased duration of estrus, number of mounts received, and quiescence between mounts compared with primiparous cows. Parity, or age effects, on estrous behavior in cattle are not consistent. Reports using visual observation concluded standing events were greater in older dairy cows compared with younger cows (De Silva et al., 1981; Gwazdauskas et al., 1983; Van Vliet and Van Eerdenburg, 1996). More recently, the number of mounts received was greater in primiparous dairy cows vs. multiparous cows monitored by a radiotelemetry system in summer months (Peralta et al., 2005). Duration of estrus and number of mounts received for primiparous cows in the current study were comparable to reports in primiparous *Bos taurus* cows (Ciccioli et al., 2003). Multiparous cows had greater BCS (mean BCS = 6.2) compared with primiparous cows (mean BCS = 4.8) at the initiation of the breeding season. Recently, we found Brahman-influenced cows in low BCS (4.2 ± 0.1) had decreased mounts received and increased quiescence between mounts compared with cows in moderate body condition (6.1 ± 0.1 ; our unpublished observations). Ciccioli et al. (2003) did not find a relationship between BCS (thin = 4.4 to moderate = 5.1) and estrous behavior in primiparous cows. Differences between studies may be due to the minimal difference between BCS for thin and moderate conditioned cows (0.7 difference in BCS) in the Ciccioli et al. (2003) study compared with a larger difference (1.9 difference in BCS) from our unpublished observations. The positive relationship between BCS and reproductive performance in cattle is well documented (Wettemann, 1980; Wettemann et al., 2003), and decreased body condition is more detrimental to the reproductive performance of primiparous cows than mature cows (Spitzer et al., 1995; Ciccioli et al., 2003). Spitzer et al. (1995) reported more primiparous cows were in estrus by d 40 of the breeding season with a BCS of 6 than cows in BCS 4 or 5.

Treatment with CIDR- $PGF_{2\alpha}$ improved synchronization rate during the first 3 d of the breeding season in both cyclic and anestrus cows. Progestin-prostaglandin combinations including norgestomet implants with $PGF_{2\alpha}$ (Heersche et al., 1979) and MGA- $PGF_{2\alpha}$ (Beal and Good, 1986) have successfully synchronized estrus in beef cattle. Similar to our results, Lucy et al. (2001) found beef cows had improved synchronized estrous rates during the first 3 d of the breeding period when treated with CIDR for 7 d and administered $PGF_{2\alpha}$ on d 6. The improved synchrony among CIDR- $PGF_{2\alpha}$ -treated cows in the current study was further evident with the decreased proportion of CIDR- $PGF_{2\alpha}$ -treated cows not detected in estrus during the first 5 to 7 d of the breeding season. First service conception rates were increased with improved synchronization among CIDR- $PGF_{2\alpha}$ treated cows during the first 3 d of the breeding season. Survival analyses revealed the benefits of improved first service conception rates for

CIDR-PGF_{2α}-treated cows by the reduction in the proportion of cows not pregnant during the first 9 d of the breeding season. Improved first service conception and 3-d pregnancy rates for anestrus cows are due to the limited number of control cows (n = 6) exhibiting estrus and becoming pregnant during the first 3 d of the breeding season compared with CIDR-PGF_{2α}-treated cows (n = 42).

In the current study, 61% of cows were anestrus at the initiation of the breeding season. Treatment with CIDR-PGF_{2α} was effective in initiating estrous cycles in anestrus cows during the first 3 and 30 d of the breeding season. The decline in the proportion of anestrus cows not detected in estrus during the first 5 d of the breeding season was more rapid in CIDR-PGF_{2α} treated cows than anestrus, control cows. Treatment with progestins has been shown to induce estrous cycles in some anestrus cows (Short et al., 1976; Miksch et al., 1978; Patterson et al., 1989), and MGA-PGF_{2α} (Beal and Good, 1986) and CIDR-PGF_{2α} (Lucy et al., 2001) combinations induced estrous cycles in anestrus cows. However, biological responses to various progestins may differ. Exposure to P₄ via CIDR for 7 d induced more early (30 d postpartum) anestrus Angus × Hereford cows to ovulate and initiate estrous cycles compared with cows treated with MGA (Perry et al., 2004). Treatment with CIDR-PGF_{2α} initiated estrous cycles in anestrus Brahman-influenced cows in the current study.

The exact mechanisms whereby treatment with P₄ via CIDR for 7 d with PGF_{2α} administered at CIDR removal initiated estrous cycles in anestrus cows are complex. Quantity of messenger RNA for LHβ subunit in the pituitary gland was increased when nutritionally anestrus cows were treated with P₄ via a CIDR for 7 d (Looper et al., 2003). Increased synthesis of LHβ could increase pituitary content of LH, thereby causing a LH surge and ovulation to occur sooner after calving. Previous research with Brahman cattle indicated cows that became pregnant had greater LH concentrations before estrus than nonpregnant cows (Godfrey et al., 1989). Progesterone administration via a CIDR for 7 d with PGF_{2α} treatment at CIDR removal probably increased concentrations of LH resulting in the initiation of estrous cycles in anestrus Brahman-influenced beef cows.

Overall, pregnancy rates averaged 80% and were not different between CIDR-PGF_{2α} and control cows. Improvements in pregnancy rates for cyclic and anestrus cows treated with a CIDR and PGF_{2α} have been somewhat inconsistent. Incorporation of a CIDR into synchronization protocols for anestrus suckled beef cows (Lamb et al., 2001) and anestrus dairy cows (El-Zarkouny et al., 2004) improved pregnancy rates. Lucy et al. (2001) reported improved pregnancy rates in CIDR-PGF_{2α}-treated cattle. However, Pursley et al. (2001) found CIDR treatment of dairy cows with the Ovsynch protocol improved pregnancy rate on d 28 in only 2 of 6 experimental sites. Pregnancy rate for timed

AI was greater in anestrus dairy cows treated with a CIDR compared with nonCIDR-treated cows (Pursley et al., 2001). Pregnancy rate for the first 3 d and the entire breeding season (75 d) was not affected by treatment with CIDR-PGF_{2α} in the current study.

Pregnancy rates tended to be greater in multiparous cows than primiparous cows in the current study. Survival curves indicated the proportion of cows not pregnant declined more rapidly for multiparous cows than primiparous cows during the first 7 d of the breeding season. El-Zarkouny et al. (2004) reported older dairy cows had greater pregnancy rates than primiparous dairy cows. An extended postpartum interval with a lower reproductive potential has been reported for 2- and 3-yr-old beef cows compared with older cows (Short et al., 1990). Body condition at breeding was greater in multiparous cows compared with primiparous cows and may have resulted in a tendency for pregnancy rates to be greater in multiparous compared with primiparous cows. Furthermore, the decline in the number of cows not observed in estrus during the first 30 d of the breeding season was more rapid in multiparous cows. This may further help explain the tendency for greater pregnancy rates observed in multiparous cows. Cyclic cows had greater pregnancy rates than anestrus cows in the current study. Several studies have reported the positive effect of the presence of luteal activity at the initiation of the breeding season on pregnancy rate in both beef (Lemaster et al., 2001; Lucy et al., 2001) and dairy (Rhodes et al., 2003; Galvão et al., 2004) cattle.

Treatment of Brahman-influenced beef cows with exogenous P₄ via a CIDR for 7 d followed by PGF_{2α} increased intensity of estrus with multiparous cows having a more intense estrus than primiparous cows. Treatment of beef cows with P₄ via a CIDR for 7 d followed by PGF_{2α} improved synchronization rate as most cows exhibited estrus within 1 to 3 d after CIDR removal and PGF_{2α} treatment. Further, CIDR-PGF_{2α} treatment initiated estrous cycles in anestrus Brahman-influenced cows. Resumption of estrous cycles with CIDR-PGF_{2α} may allow postpartum Brahman-influenced cows more time to return to estrus and aid in maintaining a yearly calving interval.

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